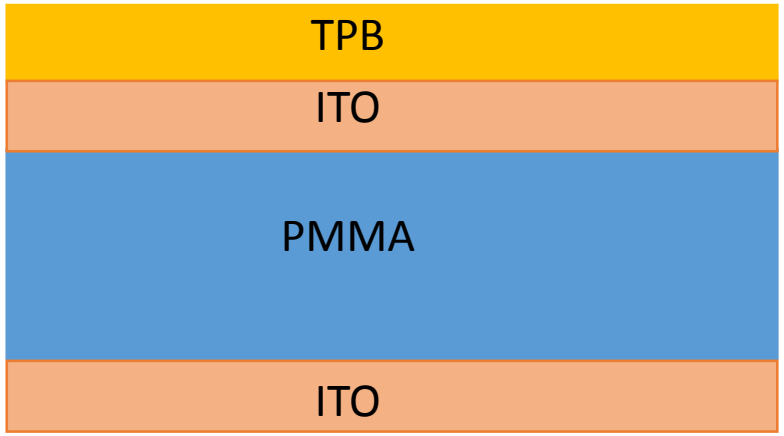
Study of the effect of the cathode plate new design on the light signal response

Anne Chappuis - **Isabelle De Bonis** - Dominique Duchesneau – Laura Zambelli

WA105 meeting – 27 Jul 2016

Preliminary implementation of the cathode plate new design in LigthSim program

Here is the cathode plate design describes in SPSC-SR-184-07-04-2016

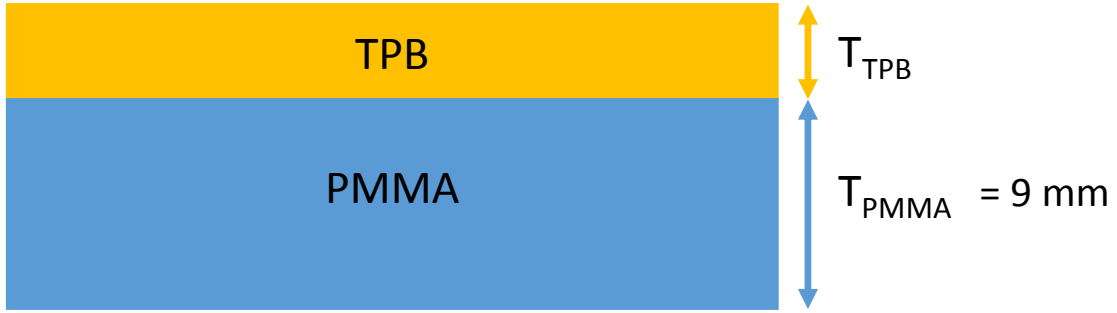


The PMMA plate has ITO coating on both sides and incorporates on the upper side a layer of TPB wavelength shifter.

T_{TPB} ~ 100 µg / cm^2 ~ 1µm

(see C. Regenfus' s presentation in TB meeting 27.4.2016)

Here is the preliminary cathode plate implementation in LightSim program



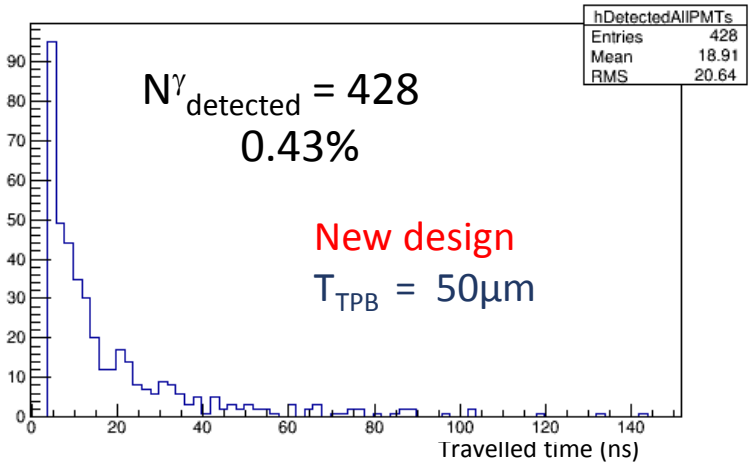
Studies are performed for 3 values of TPB layer thickness

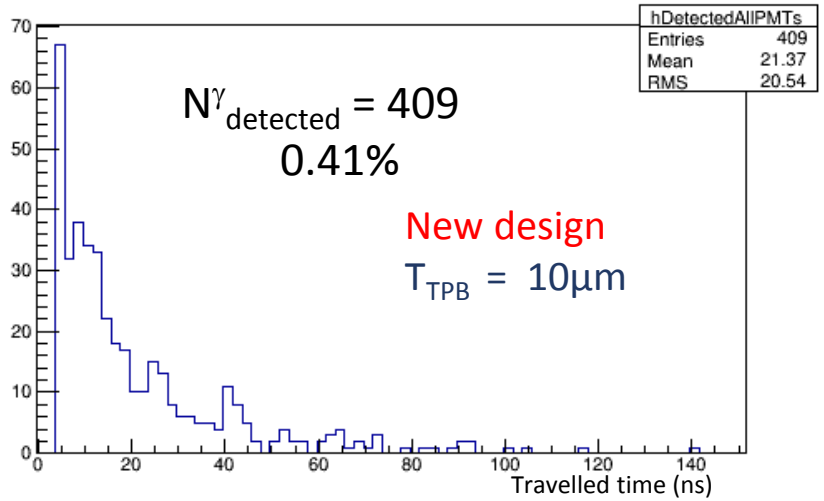
T_{TPB} = 50µm, 10µm, 2µm

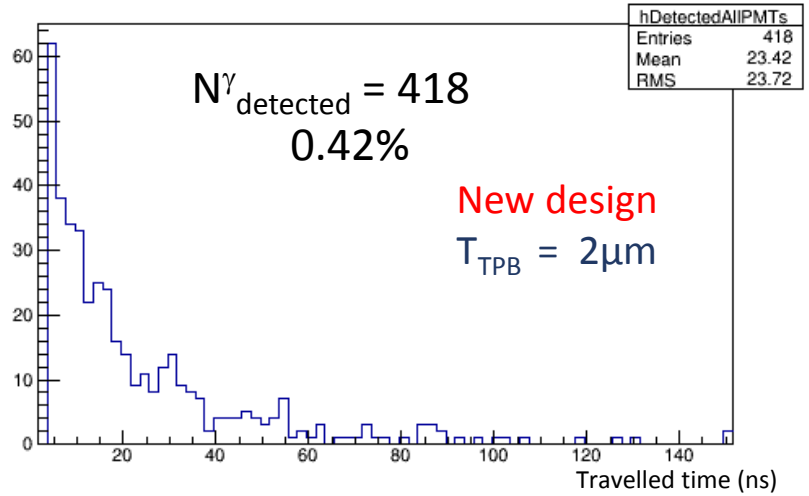
Comparison of the light signal response on all PMTs with and without cathode plate new design

10^5 photons generated near the cathode plate (X=0, Y=0, Z = - 2800 mm)

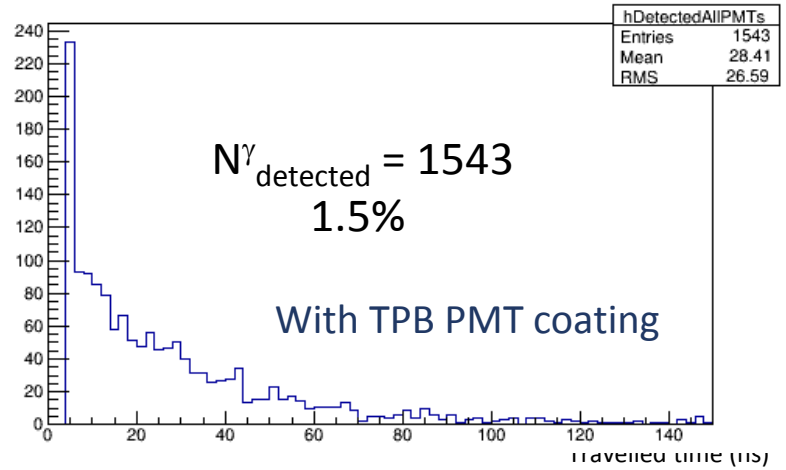
« New » design : cathode plate (TPB + PMMA layers)





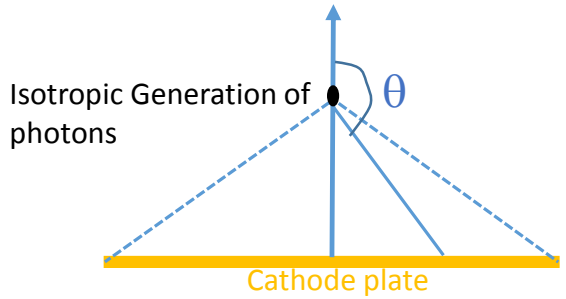


« Old » design : cathode grid + TPB coating on PMTs

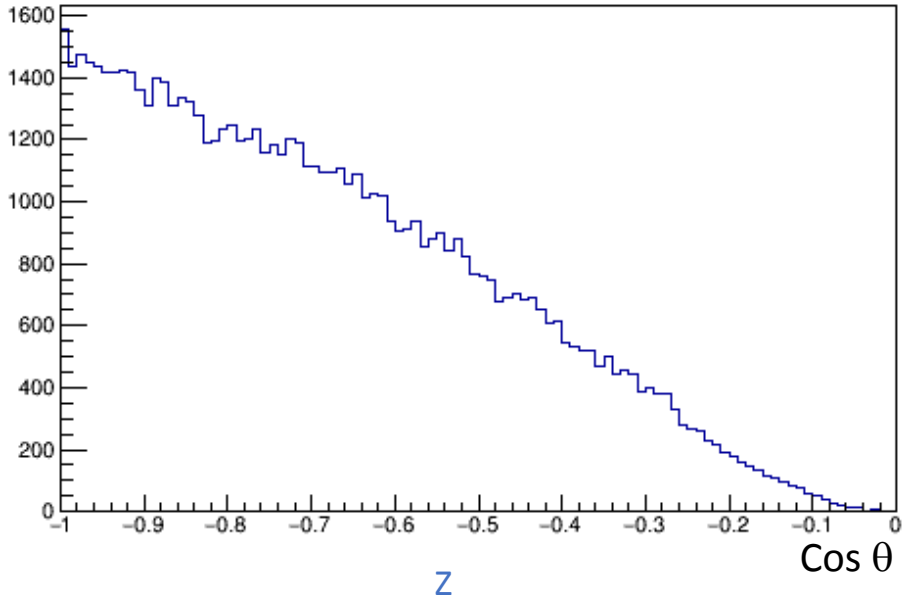


With the new plate design the light response is reduced by a factor 3

Checks on angular distribution of the photons



Cos θ distribution of photons reaching the cathode plate

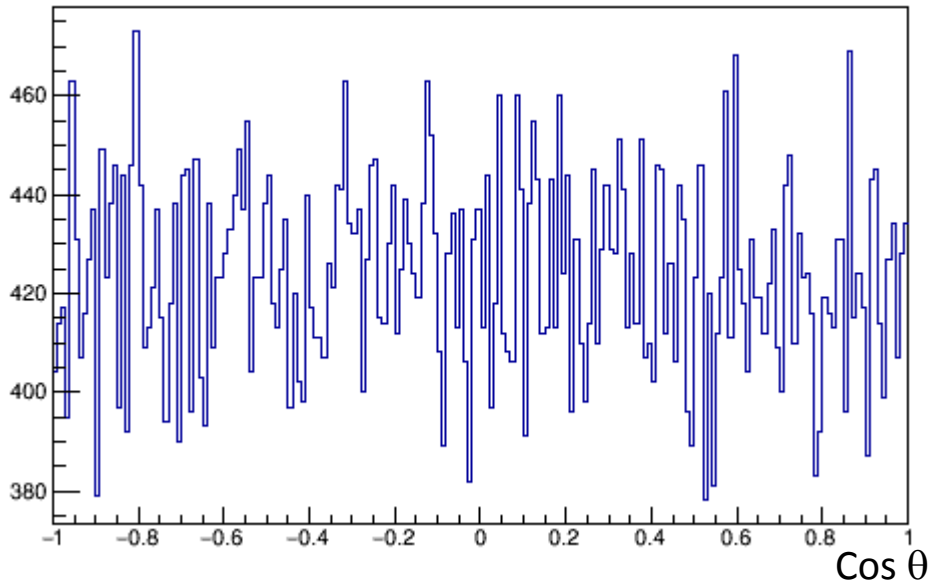


z

Photons reaching the cathode plate ~ 75 %

WLS process

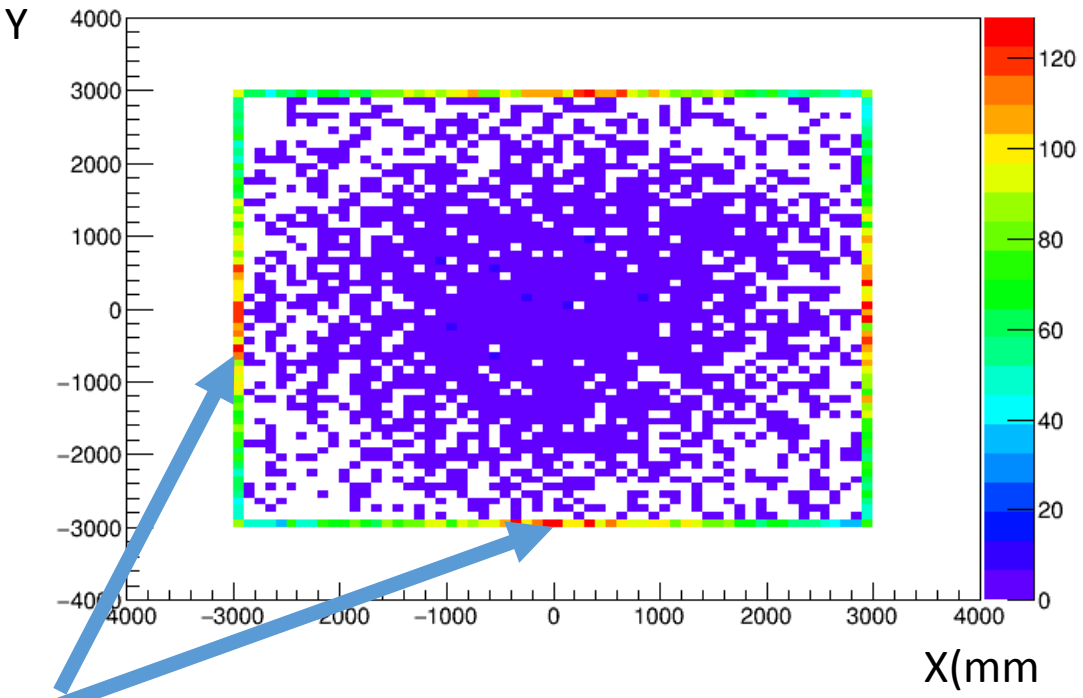
Cos θ distribution of photons after shifting



Currently In Geant4 the photons are re-emitted isotropically
Almost all photons are re-emitted

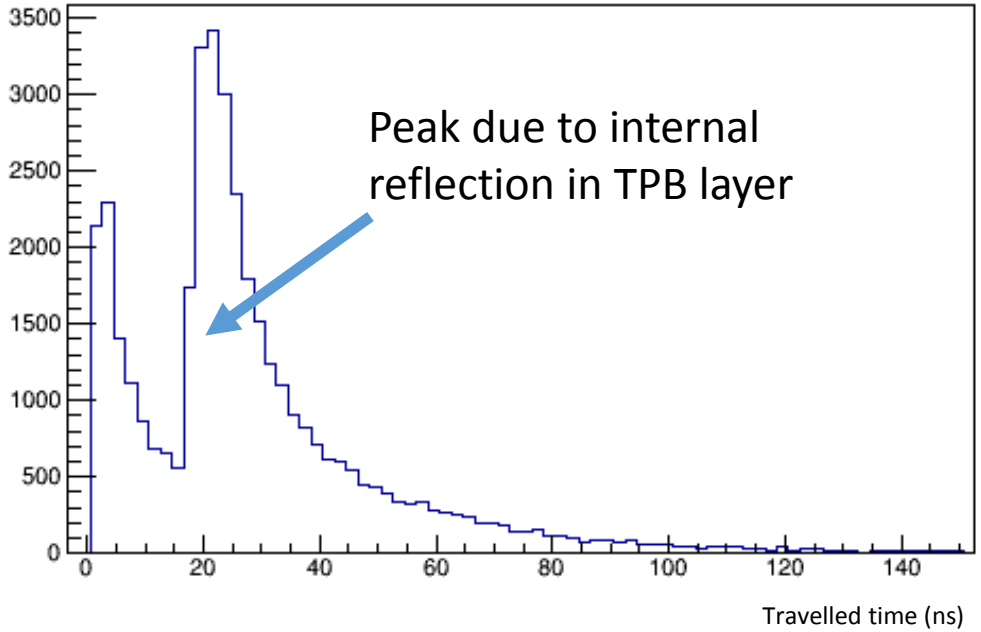
Evidence of internal reflection in TPB layer

Position of the photons
when they are refracted from TPB layer to LAr volume



photons in TPB layer due to internal reflection

Travel time distribution of the photons
when they are refracted from TPB layer to LAr volume



- On the sides of TPB layer we can see a high density of refracted photons .
- This is the result of the internal reflection in TPB layer.
- It's possible because of refractive index values $n_{TPB} = 1.635$ and $n_{LAr} = 1.25$ $n_{PMMA} = 1.48$ and the plate design of the TPB layer

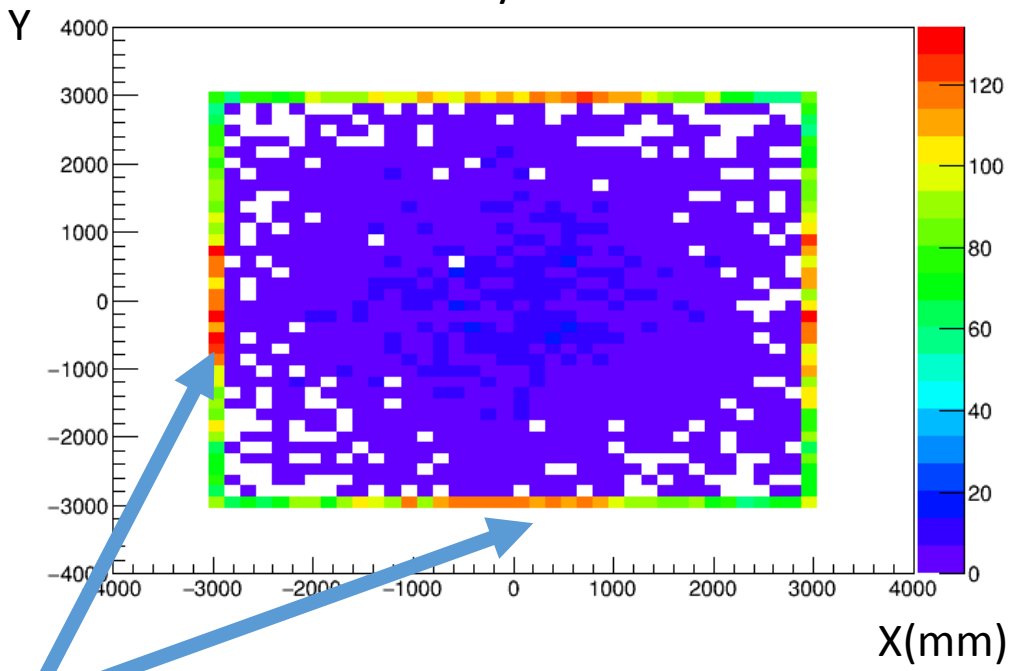
  ~ 33 % of the shifted photons are trapped into the TPB layer then refracted on the side of cathode plate in LAr.
  They are absorbed by field cage or tank surfaces and lost for the detection

  ~ 19 % of the shifted photons are refracted upward

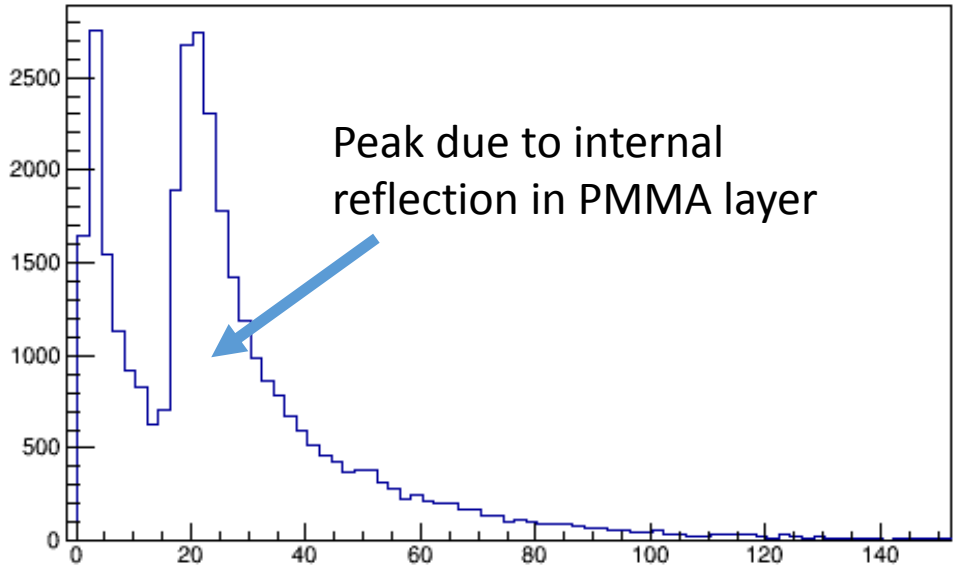
  ~ 47 % of the shifted photons are refracted into PMMA layer (N_{PMMA})

Evidence of internal reflection in PMMA layer

Position of refracted photons
from PMMA layer to LAr volume



Travel time distribution of refracted photons
from PMMA layer to LAr volume



photons in PMMA layer due to internal reflection

- Internal reflection in PMMA layer due to
  refractive indes values n_{PMMA} = 1.48 and n_{LAr} = 1.25 and the plate design of the PMMA layer

~ 55 % of N_{PMMA} photons are trapped into the PMMA layer then refracted on the side of the cathode plate in LAr
~ 44 % of N_{PMMA} photons are directly refracted into LAr volume

Conclusion

Preliminary results :

With the new plate design the light response is reduced by a factor 3

Part of this factor can be explained by the TPB and PMMA internal reflection.

Those results are compliant with the QE measurement presented in weekly meeting of 30 Apr 2015